2010-2011 TWRI Mills Scholarship Application

Applicant:
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Proposed Research

The continued depletion of fossil fuel resources and associated climate changes have created major incentives for developing renewable and sustainable bioenergy resources. Shifts in production of annual grain crops suggest large areas are available to produce annual and perennial biomass crops for conversion to biofuels. For example, the land area used for rice production has declined to 25% of peak acreages, which makes more than 450,000 acres of productive cropland available in the Gulf Coast region alone. Conservation reserve lands not suited for row crops and forest byproducts provide resources for biomass used for biofuels. Pyrolysis, one of several thermo-chemical conversion technologies available, generates liquid fuel (bio-oil) and combustible gases (synthesis gas) from diverse biomass sources in the absence of oxygen. Pyrolysis yields a charcoal byproduct, termed biochar, which could be recycled to sustain the productivity of biomass production. High contents of biochar in Brazilian Amazon soils reportedly increased surface charge densities and cation exchange capacity per unit organic C compared to soil without biochar. Other benefits of biochar include greater resistance to microbial degradation than fresh organic matter, increased N retention and aggregation of colloids in soil, and enhanced soil fertility and crop productivity.

Biomass feedstocks are considered a renewable energy resource, but intensive biomass production and repeated annual harvests deplete soil nutrients, organic matter, carbon, and vegetative cover. Complete removal of crop residues could be detrimental to crop establishment and productivity and increases sediment and nutrient transport in water runoff, which impairs water quality. Recycling and incorporating biochar from pyrolysis of biomass feedstocks could sustain soil organic C content, enhance water infiltration and storage, and reduce sediment and nutrient loss in runoff during crop establishment and after biomass harvest. Yet, relationships of biochar rates and properties to soil and water quality remain to be evaluated for biochars derived from pyrolysis systems designed for biofuel production. Biochar properties are expected to vary among feedstock sources and pyrolysis design, operation, and management. Furthermore, interactions between rates of biochar incorporation, soil properties, and water, sediment, and nutrient losses in runoff need to be evaluated.

Objectives:

1.) Relate biochar properties and application rate to soil physical, chemical, and biological properties and switchgrass seedling establishment with and without supplemental fertilizer on contrasting soil types. 2.) Compare runoff and leaching losses of water, sediment, and nutrients among treatments with and without incorporation of biochar and supplemental fertilizer at 50% and 100% switchgrass plant coverage. 3.) Evaluate the mass balance of nutrient additions in biochar, fertilizer, and soil with losses through plant uptake and runoff and leaching during switchgrass establishment.

Methods:

Three replications of four rates (0, 4, 16, and 64 Mg ha^{-1}) of biochar derived from corn stover biomass, with and without inorganic fertilizer sources of N, P, and K, will be incorporated in each a sandy loam and clay soil in box lysimeters (44-cm length x 33-cm width x 15-cm depth) under greenhouse conditions. Simulated rain (10 cm hr^{-1}) from an oscillating, indoor multiple intensity rainfall simulator will be applied to the box lysimeters at 50% and 100% switchgrass coverage of the soil. The boxes will be mounted within a metal frame beneath the simulator to impose a surface slope of 7%. During each rain event, volumes and runoff from each lysimeter box will be measured and sampled at 8-minute intervals for 24 minutes. Runoff will be collected from a flume welded to the downslope wall and leachate from a manifold linking drainage ports on the bottom of each lysimeter.

Following runoff and leachate collection, samples will be refrigerated and filtered (0.45 µm) for analysis of dissolved N, P, K, and organic C forms. Sediment collected on filters will be dried and weighed. Total N, P, K, and organic C in the unfiltered runoff will be analyzed to quantify nutrients in sediment as the difference between unfiltered and filtered runoff. Runoff and leachate volumes and nutrient and organic C concentrations of filtered and unfiltered runoff and leachate will be compared to total N, P, K, or organic C inputs in soil, biochar, inorganic fertilizer, and switchgrass to compute an overall mass balance of nutrients and carbon.

Academic Qualifications

B.S., Agricultural Engineering Technology, University of Wisconsin – River Falls
M.S. Candidate, Soil Science, Texas A&M University

Coursework:

Relevant Undergraduate Coursework	Grade	Graduate Coursework	Grade
Environmental Engineering		Soil Mineralogy	
Hydric Soils and Wetland Environments		Soil Physics	
Introduction to Soil Physics		Soil Fertility and Chemistry	
Introduction to Soil Fertility		Environmental Biophysics	
Soil Pedology		Statistics in Research I	
Soil and Water Conservation		Statistics in Research II	
Hydrology and Water Quality		**Undergraduate GPR**	
Irrigation and Drainage		**Graduate GPR**	

Presentations:

Husmoen, D. H., D. Vietor, F. Rouquette, Jr., S. Abernathy, and T. Cothren. 2010. Comparative water stress responses between bermudagrass cultivars. Texas A&M AgriLife Annual Conference, Graduate Student Poster Program.

Husmoen, D. H., and C. Clanton. 2008. Ammonia and hydrogen sulfide emissions from soil-manure mixtures in a controlled environment. Annual McNair Scholars Research Conference, Delavan, WI., Undergraduate Oral Presentation.

Proposed Use of Funds

Scholarship funds will be used to support travel and a research presentation at the 2010 ASA-CSSA-SSSA International Annual Meetings in Long Beach, CA. Anticipated travel expenses include meeting registration, transportation, and lodging. Remaining funds will be used for tuition and fees for the Fall 2010 semester.

Intended Career Path

Upon completion of my M.S. degree in Soil Science in the spring of 2011, I intend to pursue a career in soil conservation and land and nutrient management. My education and research experience related to bio-resource cycling, coupled with life experiences on my family's dairy farm, will enable me to advise and enable agricultural producers and operations to be economically viable while providing essential ecosystem services. Specifically, I am interested in soil fertility, soil and water conservation, impacts of manures and fertilizers on surface water contamination and runoff, and on-farm energy generation through anaerobic digesters, methane digesters, and thermo-chemical processes. My career goal is to work for the USDA-Natural Resources Conservation Service as a soil scientist or soil conservationist.